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CULTURE EXPERIMENTS WITH MELAMPSORA IN JAPAN

TAKASHI MATSUMOTO

Graduate Student in the Henry Shaw School of Botany of Washington University

Culture experiments with the heteroecious rust *Melampsora* have been extensively undertaken by investigators in different countries, especially in Germany. However, owing to the diversity of local conditions and also the variability of the fungi themselves, the data which are secured in one country can not readily be accepted in others. The life histories of such heteroecious forms, therefore, require to be worked out for each country separately.

In the writer's first article ('15) of this study, the inter-relationships between the different spore types of a few species of *Melampsora* and the host species of *Salix* plants were for the first time reported in Japan. The life histories which have already been determined and reported by me are for the five species arranged in the following key:

KEY TO THE SPECIES

- A. Teleutospores subepidermal.
 - a. Teleutospores amphigenous and uredospores hypophyllous. 1
 Uredospores $15-20 \times 12-15 \mu$. Teleutospores $26-37 \times 8-13 \mu$.
 On *Salix opaca* Anders. 1. *M. Larici-opaca* Miyabe and Matsumoto
 - b. Teleutospores and uredospores mostly hypophyllous. 2
 Uredospores $15-22 \times 12-16 \mu$. Teleutospores $18-40 \times 7-11 \mu$.
 On *Salix Miyabeana* v. Seem. 2. *M. Larici-Miyabeana* Miyabe and Matsumoto
- B. Teleutospores subepidermal, frequently subcuticular.
 - a. Teleutospores amphigenous, but mostly epiphyllous. Uredo-
 spores hypophyllous. 3, 4
 Uredospores $13-19 \times 11-15 \mu$. Teleutospores $30-58 \times 8-13 \mu$.
 On *Salix viminalis* L. 3. *M. Larici-epitea* Kleb.
 Uredospores $14-18 \times 11-14 \mu$. Teleutospores $30-55 \times 8-14 \mu$.
 On *Salix daphnoides* Vill. 4. *M. Larici-daphnoides* Kleb.
- C. Teleutospores subcuticular.
 - a. Teleutospores amphigenous, but mostly epiphyllous. Uredo-
 spores mostly hypophyllous, frequently amphigenous. 5
 Uredospores $18-29 \times 12-16 \mu$. Teleutospores $20-30 \times 8-12 \mu$.
 On *Salix jessoensis* v. Seem. 5. *M. yezoensis* Miyabe and Matsumoto

Since additional cultural results with *Melampsora* on species of *Salix* and *Populus* have been secured since the positive results in 1915, on the species mentioned above, supplementary notes are given later in the present paper.

MELAMPSORA ON SALIX URBANIANA V. SEEM.

In April, 1916, a large number of inoculations of *Larix decidua* with *Melampsora* obtained from *Salix Urbaniana* were undertaken for the purpose of verifying the results published in my earlier paper. Positive results were readily secured on *Larix decidua*, as shown in table I, while on the remaining species the inoculations were unsuccessful.

In May, 1916, several series of infection experiments were performed by the inoculation of *Salix Urbaniana* with the caeomaspores which had been produced on *Larix decidua*. After a week positive results were secured.

TABLE I
SHOWING THE RESULTS OF INOCULATION WITH MELAMPSORA
FROM SALIX URBANIANA

Inoculation material	Species inoculated	Date of inoculation	Result	Date of first sori
Teleutospores from				
<i>Salix Urbaniana</i>	<i>Larix decidua</i>	April 28	+	May 15
<i>Salix Urbaniana</i>	<i>Salix Urbaniana</i>	April 28	—	
<i>Salix Urbaniana</i>	<i>Allium Cepa</i>	April 28	—	
<i>Salix Urbaniana</i>	<i>Chelidonium majus</i>	April 28	—	
Caeomaspores from				
<i>Larix decidua</i>	<i>Salix Urbaniana</i>	May 18	+	May 25

From the experiments it is evidently established that the species on *Salix Urbaniana* found in Sapporo, Japan, is heteroeocious and must have its aecidial stage on *Larix* sps. In consideration of the evidence given, as well as that which follows, I consider this a new species, and the accompanying diagnosis and notes are offered:

Melampsora Larici-Urbani Matsumoto, n. sp.

Aecidiospores. Caeomata hypophyllous, scattered, pale orange-yellow with yellow spots on the upper surface, roundish

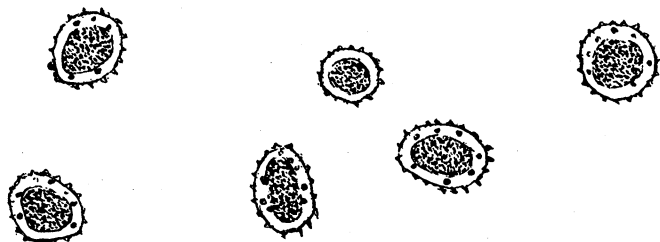


Fig. 1. *Melampsora Larici-Urbani*. Caeomasporae. Camera lucida drawing $\times 460$.

or oblong; spores roundish or oval, finely echinulate, $15-26 \times 13-19 \mu$; membrane hyaline, $3-4 \mu$ thick.

Uredospores. Sori hypophyllous, densely scattered over the whole lower surface, with yellow spots showing on the upper



Fig. 2. *Melampsora Larici-Urbani*. Uredospores. Camera lucida drawing $\times 460$.

surface, seated on small orange-yellow spots; spores mostly oval, sometimes oblong or roundish, with a more or less elongated stalk, $15-26 \times 12-17 \mu$; membrane hyaline, echinulate, without perceptible germ pore; paraphyses capitate, with a thin pedicel ($3-4 \mu$), $50-70 \times 18-22 \mu$.

Teleutospores. Sori hypophyllous, dark reddish brown, scattered over the whole surface or confluent in excessive crusts, covered by the epidermis; spores prismatic, rounded at both

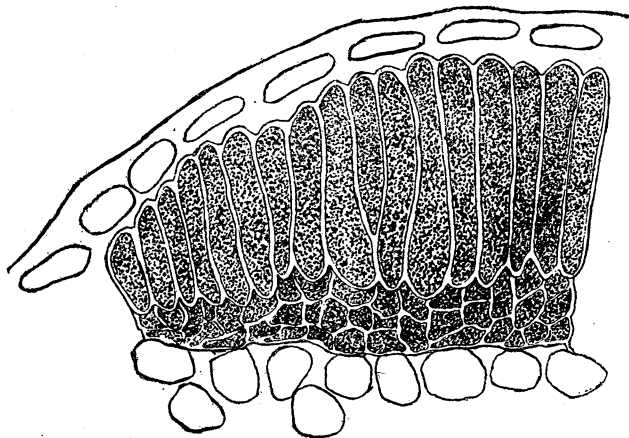


Fig. 3. *Melampsora Larici-Urbaniana*. Teleutospores. Camera lucida drawing $\times 460$.

ends, $38-70 \times 9-15 \mu$; membrane somewhat brown, uniformly thin, without an evident germ pore; contents orange-red; sporidia spherical, $9-15 \mu$.

Caeomata on *Larix decidua*; uredo- and teleutospores on *Salix Urbaniana*.

This species is more or less related to *Melampsora Larici-pentandrae* Kleb., as shown by the position of the teleutospore layer, by the thickness of the apical cell-wall, and by having the *Caeoma* stage on the leaves of *Larix* sps. On the other hand, there are characteristic differences, as follows: (1) The uredospore layer of the fungus in question is hypophyllous, while that of the other is epiphyllous; (2) The uredospores of our species are considerably shorter than the spores described by Klebahn ($26-44 \times 12-16 \mu$); (3) The teleutospores of our form are so decidedly larger that even the smallest can hardly be compared with the largest of the spores described by Klebahn ($28-38 \times 6-11 \mu$).

MELAMPSORA ON POPULUS BALSAMIFERA

As already stated in my previous paper, the author noticed an abundance of *Caeoma* on the leaves of *Chelidonium majus* at

Nakajima Park, Sapporo, where there were growing many species of *Populus* badly attacked by the *Melampsora* rusts. These indications, in the light of results obtained by Klebahn in Germany, induced me to assume that there might be some relationship between the *Caeoma* on *Chelidonium* and the *Melampsora* on some species of *Populus*. However, in the inoculation of *Chelidonium* with *Melampsora* from *Populus* (1915), no light could be thrown on this subject; therefore in the following year additional cultures were made, but these also failed to yield any positive results.

After these successive negative results, the writer made cultures with species of *Melampsora* from *Populus balsamifera* on *Larix leptolepis*, *Larix decidua*, *Ribes grossularia*, and *Allium Cepa*. A study of the data in table II shows that the sporidia of the rust on *Populus balsamifera* infect *Larix leptolepis* and *Larix decidua* without any apparent preference, while on the remaining plants they prove to be quite ineffective.

TABLE II
SHOWING THE RESULTS OF INOCULATIONS WITH MELAMPSORA
FROM POPULUS BALSAMIFERA

Inoculation material	Species inoculated	Date of inoculation	Result	Date of first sori
Teleutospores from				
<i>Populus balsamifera</i>	<i>Larix leptolepis</i>	May 2	+	May 18
<i>Populus balsamifera</i>	<i>Larix decidua</i>	May 2	+	May 19
<i>Populus balsamifera</i>	<i>Ribes grossularia</i>	May 2	—	
<i>Populus balsamifera</i>	<i>Allium Cepa</i>	May 2	—	
Caeomasporos from				
<i>Larix decidua</i>	<i>Populus balsamifera</i>	May 24	+	June 8

The species can properly be regarded as *Melampsora Larici-populina* Kleb. on account of the position of the uredo- and teleutospore layer and the relationship between the different spore forms and the host plants. The author observes some

difference in size between both the caeoma- and the teleutospores of species from the two sources, but these points alone are not sufficient to be considered as of specific importance.

The characterization of the species is as follows:

Melampsora Larici-populina Kleb.

Aecidiospores. Caeomata hypophyllous, single or in groups, with yellow spots on the upper surface, roundish or oblong, 1–1.5 mm. in diameter, orange-red, pulverous; spores roundish or oval, finely and densely verruculose, $22-37 \times 18-27 \mu$.

Uredospores. Sori mostly hypophyllous, seated on yellow spots, scattered over the whole surface, orange-yellow, pulverous; spores oval or elongated, $26-40 \times 16-22 \mu$; membrane hyaline, finely echinulate, without perceptible germ pore; paraphyses capitate, with a slender pedicel, $16-22 \times 55-80 \mu$.

Teleutospores. Sori epiphyllous, frequently hypophyllous, dark reddish brown, scattered or in groups over the whole surface, covered by the epidermis; spores cylindrical or somewhat wedge-shaped, $18-48 \times 8-12 \mu$; membrane clear brown, uniformly thin, without an evident germ pore; sporidia spherical.

Caeomata on *Larix leptolepis* and *Larix decidua*; uredo- and teleutospores on *Populus balsamifera*.

MELAMPSORA ON SALIX BABYLONICA

When negative results were obtained as to any relationship between Caeoma on *Chelidonium* and *Melampsora* on *Populus*, the author performed a new experiment by inoculating *Chelidonium majus* with teleutospore material obtained from several species of *Salix* and *Populus*.

As will be shown in the data of table III, successful results were only secured by sowing the teleutospore material obtained from *Salix babylonica*.

As may be easily seen, the species on *Salix babylonica* requires *Chelidonium majus* for complete development of its entire life cycle, but owing to the fact that no return infections to *Salix* sps. have been made, the subject has not yet been completely established.

The aecidial stage resulting from the successful inoculation

TABLE III
SHOWING THE RESULTS OF INOCULATIONS OF CHELIDONIUM
WITH TELEUTOSPORES

Inoculation material	Date of inoculation	Result	Date of first sori
Teleutospores from			
<i>Salix Capraea</i>	June 10	—	
<i>Salix babylonica</i>	June 10	+	June 21
<i>Populus nigra</i>	June 10	—	
<i>Populus balsamifera</i>	June 10	—	

with the teleutospores obtained from *Salix babylonica* may be described as follows:

Aecidiospores. Caeomata hypophyllous, clustered or isolated, with yellow spots on the upper surface, small, roundish; spores roundish or oblong, $14-18 \times 13-17 \mu$; membrane hyaline, finely verruculose.

MELAMPSORA ON SALIX CAPRAEA

From the fact that our Japanese *Melampsora* on *Salix Capraea* is morphologically more or less similar to *Melampsora Larici-Capraearum* described by Klebahn, the writer was inclined to assume that the first-named form might have its aecidial stage on *Larix* sps., consistent with the observations made in Germany.

In April, 1916, a large number of experiments were undertaken by inoculating *Larix decidua* with sporidia obtained from the teleutospore stage on *Salix Capraea*, but no successful result has been secured. According to von Tubeuf, successful results were obtained by sowing *Caeoma Abietis pectinatae* upon *Salix Capraea*. I have been unable to establish this relationship.

SUMMARY

1. A *Melampsora* on *Salix Urbaniana* requires *Larix* sps. for the completion of its life cycle. For this species the name *Melampsora Larici-Urbaniana* Matsumoto is proposed.

2. A *Melampsora* on *Populus balsamifera* found in Japan is identified with *Melampsora Larici-populina* described by Klebahn in Germany.

3. A *Melampsora* on *Salix babylonica* has its *Caeoma* stage on the leaves of *Chelidonium majus*. Owing to the lack of infection experiments with the alternate host the relationship has not yet been completely established.

4. A *Melampsora* on *Salix Capraea* seems to have a *Caeoma* stage neither on the leaves of *Larix* sps. nor *Abies* sps.

The author wishes to express here his heartiest thanks to Dr. K. Miyabe to whom he is indebted for many valuable suggestions, likewise to Dr. B. M. Duggar for his kindly advice and criticism. Thanks are also due Dr. G. T. Moore for the privileges of the library.

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